ECE 6532 / CS 6640/ BIOEN 6640 Image Processing
Assignment 2

General guidelines:

- **Deadline: October 5, 23:59.**
- For book questions, reference for 3rd edition as well as International editions are provided. However, please make sure to validate question numbers in your book with a 3rd edition.

MATLAB question guidelines:

- Name the .m files with the same name as the function.
- You are not allowed to use any functions from the MATLAB Image Processing Toolbox or any other toolboxes in your methods. Only functions that are part of the basic MATLAB package may be used.

Submission guidelines:

- All submissions must be done using Canvas.
- The submission should contain exactly two files - report (pdf) and code + data (zip).
- For theoretical questions, it is preferred to type in a text editor. Scanned hand written submissions will also be accepted, however, students must ensure that scan quality as well as written text is clear for TA to understand.
- Answers to theoretical questions should be as concise and precise as possible.
- For programming questions, report should contain following:
  - You are required to explain your understanding of the question.
  - Technical details of the method such as any parameters used. If you find a specific value works best, a discussion on findings using other values is required OR the process involved in finding correct set of parameters. You are encouraged to play with different parameter values and discuss and findings.
  - Results and discussion: report the findings and discuss output images with respect to input images and expected output. It is preferable to add any contradictory results, if found, with brief comments about why it should/not be.
- Report would be used for evaluation and code might be verified for correctness as well as to match the results. Results in the report must correspond to results obtained from running the code.

QUESTIONS

1. Question 3.14 from textbook.
2. Question 3.17 from textbook.
3. Question 3.28 from textbook.
4. Thresholding and adaptive contrast enhancement.
   (a) Write a function that splits an image into non-overlapping 32×32 blocks and applies an intensity transformation in each block such that in the output image each of the blocks have mean intensity 128 and standard deviation 50. The function should be in the following format:
   `function Io = AdaptiveEqualize (I)`
   where I is the input image and Io is the output image.

(b) Compare / discuss the results obtained by the following two thresholding approaches to segment the ridges of the fingerprint image

- Load the fingerprint image from the example images on the class webpage and apply Otsu's thresholding to it (use the Otsu function from the class webpage).
- This time first apply your AdaptiveEqualize function to the original fingerprint image and then apply Otsu's method to the resulting image.

5. Gaussian and Bilateral filtering.

a) Implement a Gaussian (domain) smoothing filter. The function should be in the following format:

```
function Io = GaussianFilter (I, sigma)
```

where I is the input image, *sigma* is the standard deviation of the Gaussian and Io is the filtered output image. You should truncate the Gaussian at $3 \times sigma$ for computing the summation.

b) Implement bilateral filtering for intensity images given by the discrete versions of equations (5) and (6) in the paper. (We showed how to do this in class). Use two Gaussian functions for c and s as described in Section 2.1 of the paper. The function should be in the following format:

```
function Io = BilateralFilter (I, sigmad, sigmar)
```

where I is the input image, *sigmad* is the standard deviation of the domain Gaussian, *sigmar* is the standard deviation of the range Gaussian and Io is the filtered output image.

c) Try the Gaussian filter on the *Lena* image with $sigma = 3$. Try the bilateral filter on the *Lena* image with $sigmad = 3$ and $sigmar = 10$. What are the differences?

d) For both outputs in c) above, display the absolute value of the difference between the input image and the processed output. Looking at this residual is one way to observe the effects of a filter. What differences do you see?

e) Try the bilateral filter with $sigmad = 3$ and $sigmar = 100$ and look at the residual again. What changed?

f) What happens to the function c as $sigmad \to \infty$? What is the bilateral filter equivalent to in this case?

g) What happens to the function s as $sigmar \to \infty$? What is the bilateral filter equivalent to in this case?

6. Load the image *house.pgm* into a variable named f. Convert f to double then add Gaussian noise with standard deviation 20 using the command

$$g = f + 20 * randn(size(f))$$

(a) Filter g with your Gaussian filter using a standard deviation $sigma = 3$. Report the Mean Square Error (MSE) of the noisy image and the filtered image.

(b) Filter g with the Bilateral filter using a domain Gaussian standard deviation $sigmad = 3$ and trying the following standard deviations for the range Gaussian: $sigmar = 5, 10, 20, 40, 60, 100$. Compute the MSE values for each selection of *sigmar* and make a plot of MSE vs. *sigmar*. Briefly comment on this plot.